



GEOSYNTHETIC REINFORCED SOIL SLOPE SYSTEM MSP-97-09D

1.0 Description. Work shall consist of design, furnishing materials, and construction of geosynthetic reinforced soil slope (GRSS) structure meeting approval of the Engineer. Design and supply of geosynthetic reinforcement, drainage composite, and erosion control materials, and site assistance are all to be furnished by the slope system supplier.

2.0 Prequalification of Reinforced Slope System and Materials. All systems and materials shall be pre-qualified and approved before the contract is awarded. To apply for prequalification or prequalification requirements, the supplier or manufacturer shall submit a request to Construction and Materials. The following systems are prequalified and may be used:

Tensar Sierra Slope Retention System:

Tensar Earth Technologies, Inc.
5883 Glenridge Drive
Suite 200
Atlanta, GA 30328-5363

phone 404-250-1290
sales 800-202-4459
fax 404-250-0461

Mirafi Geogrid Reinforced Slope:

Ten Cate Nicolon USA
365 South Holland Drive
Pendergrass, GA 30567

phone 706-693-2226
fax 706-693-4400
email: tc mirafi@rtcusa.net

3.0 Preliminary Design and Plans.

3.1 Prior to any work being done, GRSS design plans and computations shall be submitted to the engineer complete with all details as a separate submittal for each individual reinforced slope structure.

3.2 All drawings shall be clear and complete. Six sets of drawings of the completed wall design plans shall be submitted for distribution. The drawings submitted shall be legible and have distinct details of sufficient contrast to be suitable for microfilming. Drawings which do not have the desired clarity and contrast will be returned for corrective action. The GRSS system manufacturer shall be solely responsible for the content of the design plans.

3.3 All GRSS design plans submitted for distribution shall be signed, sealed and stamped in accordance with the laws relating to architects and professional engineers (Chapter 327, RSMo.).

3.4 The minimum factors of safety for slope stability shall be as follows or as required by the contract.

3.4.1 1.5 against horizontal sliding of the reinforced mass along its base

3.4.2 1.3 against external, deep seated failures

3.4.3 1.3 against compound failure surfaces

3.4.4 1.3 against internal failure

3.4.5 1.1 seismic loading for the above failure modes

3.5 Reinforced slopes shall be designed for the appropriate SEISMIC PERFORMANCE CATEGORY A, B, C, or D and additional requirements as maybe shown in the plans or this specification.

3.6 Completed GRSS design plans shall also contain all material specifications, fabrication requirements, and all construction requirements for erecting the reinforced slope complete in place. Any requirements on the design plans conflicting with this special provision shall not be used.

3.7 The effect of construction damage test shall be incorporated into the construction damage factor F_c , that is applied to the limit and serviceability state reinforcement tensions. Where construction tests have been made, but with fills or construction procedures other than those representative or site specific on the project, the minimum value of F_c shall be taken as 1.25. Lower values of F_c may be only used if substantiated with damage test using fills and construction procedures specific to the project. A default F_c value of 3.0 shall be used in the absence of any construction tests.

4.0 Backfill Material.

4.1 Backfill material for GRSS shall conform to the following requirements.

4.2 Backfill shall be gravel, stone, sand or any combination, conforming to the following gradation limits:

Sieve Size	Percent Passing
¾ inch (19 mm)	100 – 75
No. 4 (4.75 mm)	100 – 20
No. 40 (425 µm)	0 – 60
No. 200 (75 µm)	0 - 50

4.3 The plasticity Index, as determined by AASHTO T-90, shall not exceed 20.

4.4 The material shall substantially be free of shale or other soft, poor durability particles and shall have a magnesium sulfate soundness loss of less than 30 percent after four cycles as determined by AASHTO T-104.

4.5 Backfill materials shall meet the following electrochemical requirements:

Requirements	Test Methods
ph 4.5-9.5	AASHTO T-289-91
Organic Content < 1%	AASHTO T-267-86
Chlorides < 100 ppm	AASHTO T-291-91
Sulfates < 200 ppm	AASHTO T-290-91

4.6 The contractor shall furnish to the engineer a Certificate of Compliance certifying the selected granular backfill material complies with this section of the specifications. A copy of test results from an approved laboratory testing the material for all of the above requirements shall also be furnished to the Engineer. Tests shall apply specifically to the material being used and shall not be more than twelve months old, if previously tested for another job and still applicable.

4.7 Acceptance will be based on the Certificate of Compliance, accompanying test reports, and any applicable tests performed by the Engineer.

5.0 Design and Plan Requirements.

5.1 The final design to be submitted after contract award shall include detailed design computations and all details, dimensions, quantities and cross sections necessary to construct the slope(s). The fully detailed plans shall be prepared to MoDOT standards and shall include, but not be limited to, the following items:

5.1.1 An elevation view indicating elevations at top and bottom of slope, beginning and end stations, all horizontal and vertical break points, whole station points, and each level of reinforcement. Location of proposed final ground lines shall be indicated.

5.1.2 Length, size, and type of grade of reinforcement shall be shown.

5.1.3 Internal drainage alignment, elevations, and slope face exit points shall be shown on the elevation, plan, and cross section views.

5.1.4 Plan view shall reflect the horizontal alignment and shall indicate the offset from the horizontal control line to the front face of the slope. All utilities, signs, lights, etc. that effect the reinforced slope shall be shown.

5.1.5 Any general notes required for construction of the reinforced slope.

5.1.6 Cross sections showing limits of construction, fill requirements, and excavations limits.

5.1.7 Limits and extent of reinforced soil fill volume

5.2 Typical Details of Primary and Secondary Reinforcement.

5.2.1 Facing details for erosion control.

5.2.2 Temporary slope face support (if required).

5.2.3 All details for construction of slope around drainage facilities, overhead sign footings and abutments shall be clearly shown.

5.3 Detailed Design Computations.

5.3.1 Slope stability computations, computer output, and an explanation of analysis details within the program. A copy of the computer program with user documentation if an in-house computer program was used.

5.3.2 Cross section plots showing critical failure planes for internal, compound, and global failure modes; and a summary of the critical failure surface(s) search.

5.3.3 Sliding stability computations.

5.3.4 Seismic stability computations, where applicable.

5.3.5 Tractive shear stress of all erodible surfaces and appropriate anchorage mechanism(s). (Erosion protection requirements to be specified by MoDOT.)

5.3.6 Drainage system design computations including volume of water to be removed by the subsurface drainage system; geotextile retention, permeability, and survivability requirements based upon fill and subgrade characteristics; and maximum longterm flow of the drainage composite. (Maximum drain spacing and flow requirements to be specified by MoDOT.)

5.4 The plans and design computations shall be prepared and sealed by a professional engineer, licensed according to Chapter 327, RSMo. Six sets of design drawings and detail design computations shall be submitted to MoDOT. The computations shall include a detailed explanation of any symbols and computer programs used in the design. All design and construction details will be checked by MoDOT against the preapproved design values and procedures for materials approved for use in that particular system.

6.0 Construction Requirements.

6.1 Delivery, storage, and handling of geosynthetic reinforcement, drainage composite, and geosynthetic erosion mat shall comply with requirements set forth in the Missouri Standards Specifications for Highway Construction.

6.2 Geosynthetic reinforcement material suppliers shall provide a qualified and experienced representative on site, for a minimum of three days, to assist the contractor and MoDOT inspectors at the start of construction. If there is more than one slope on a project, then this criteria will apply to construction of the initial slope only. The representative shall also be available on an as needed basis, as requested by the Engineer, during construction of the remaining slope(s).

6.3 All areas immediately beneath the installation area for the geosynthetic reinforcement shall be properly prepared as detailed on the plans, specified elsewhere within the specifications, or directed by the Engineer. Subgrade surface shall be level, free from deleterious materials, loose or otherwise unsuitable soils. Prior to placement of geosynthetic reinforcement, subgrade shall be proof-rolled to provide a uniform and firm surface. Any soft areas, as determined by the Engineer, shall be excavated and replaced with suitable compacted materials. Foundation surface shall be inspected and approved by the Engineer prior to fill placement. Benching the backcut into competent soil is recommended to improve stability.

6.4 Geosynthetic reinforcement shall be installed within the layers of the compacted soil in accordance with the manufacturer's recommendations and as shown on the plans. Geosynthetic reinforcements are to be placed within 3 inches (75 mm) of the design elevations and extend the length as shown on the elevation view unless otherwise directed by the Engineer. Correct orientation of the geosynthetic reinforcement shall be verified by the contractor.

6.5 Backfill shall be placed, spread, and compacted in such a manner to minimize the development of wrinkles and/or displacement of the geosynthetic reinforcement. Cohesive soils shall be compacted in a maximum loose lift thickness of 8 inches (200 mm), and granular soils in a maximum loose lift thickness of 10 inches (250 mm). Backfill shall be compacted as specified by project specifications or to at least 95 percent of the maximum density determined in accordance with AASHTO T-99, whichever is greater. Backfill shall be graded away from the slope crest and rolled at the end of each work day to prevent ponding of water on surface of the

reinforced soil mass. Tracked construction equipment shall not be operated directly upon the geosynthetic reinforcement. A minimum fill thickness of 6 inches (150 mm) is required prior to operation of tracked vehicles over the geosynthetic reinforcement. Turning of tracked vehicles shall be kept to a minimum to prevent tracks from displacing the fill and the geosynthetic reinforcement. If approved by the Engineer and subject to satisfactory performance, rubber tired equipment may pass over the geosynthetic reinforcement at speeds no greater than 10 mph (16 km/h). Sudden braking and sharp turning shall be avoided.

6.6 Erosion Control Material Installation.

6.6.1 Delivery, Storage, and Handling. Contractor shall check the erosion control material to ensure that the proper material has been received. During all periods of shipment and storage, the erosion mat shall be protected from temperatures greater than 140 F (60 C), mud, dirt, and debris. Follow manufacturer's recommendations in regards to protection from direct sunlight. At the time of installation, the erosion mat/blanket shall be rejected if it has defects, tears, punctures, flaws, deterioration, or damage incurred during manufacture, transportation, or storage. If approved by the engineer, torn or punctured sections may be removed by cutting a cross section of the mat out. The remaining ends should be overlapped and secured with ground anchors. Any erosion mat/blanket damaged during storage or installation shall be replaced by the contractor at no additional cost to MoDOT.

6.6.2 On Site Representative. Erosion control material suppliers shall provide a qualified and experienced representative on site, for a minimum of one day, to assist the contractor and MoDOT inspectors at the start of construction. If there is more than one slope on a project then this criteria will apply to construction of the initial slope only. The representative shall also be available on an as needed basis, as requested by the engineer, during construction of the remaining slope(s).

6.6.3 Placement. The erosion control material shall be placed and anchored on a smooth graded, firm surface approved by the engineer. Anchoring terminal ends of the erosion control material shall be accomplished through use of key trenches. The material in the trenches shall be anchored to the soil on maximum 18 inch (450 mm) centers. (Topsoil, if required by construction drawings, placed over final grade prior to installation of the erosion control material shall be limited to a depth not exceeding 3 inches (75 mm).

6.6.3.1 Erosion control material shall be anchored, overlapped, and otherwise constructed to ensure performance until vegetation is well established. Anchors shall be as designated on the construction drawings, with a minimum length of 12 inches (300 mm) recommended, and shall be spaced as designated on the construction drawings, with a maximum spacing of 4 feet (1.2 m) recommended.

6.6.4 Soil Filling. If noted on the construction drawings, the erosion control mat shall be filled with a fine grained topsoil, as recommended by the manufacturer. Soil shall be lightly raked or brushed on/into the mat to fill mat thickness or to a maximum depth of 1 inch (25 mm).

6.7 Geosynthetic Drainage Composite.

6.7.1 Delivery, Storage, and Handling. Contractor shall check the erosion control material to ensure that the proper material has been received. During all periods of shipment and storage, the erosion mat shall be protected from temperatures greater than 140 F (60 C), mud, dirt, and debris. Follow manufacturer's recommendations in regards to protection from direct sunlight. At the time of installation, the erosion mat/blanket shall be rejected if it has defects, tears,

punctures, flaws, deterioration, or damage incurred during manufacture, transportation, or storage. If approved by the engineer, torn or punctured sections may be removed by cutting a cross section of the mat out. The remaining ends should be overlapped and secured with ground anchors. Any erosion mat/blanket damaged during storage or installation shall be replaced by the contractor at no additional cost to MoDOT.

6.7.2 On Site Representative. Geosynthetic drainage composite material suppliers shall provide a qualified and experienced representative on site, for a minimum of one half day, to assist the contractor and MoDOT inspectors at the start of construction with directions on the use of drainage composite in conjunction with the geosynthetic reinforced soil system. If there is more than one slope on a project then this criteria will apply to construction of the initial slope only. The representative shall also be available on an as needed basis, as requested by the engineer, during construction of the remaining slope(s).

6.7.3 A geotextile flap shall be provided along all drainage core edges. This flap shall be of sufficient width for sealing the geotextile to the adjacent drainage structure edge to prevent soil intrusion into the structure during and after installation. The geotextile shall cover the full length of the core.

6.7.4 The geocomposite core shall be furnished with an approved method of constructing and connecting with outlet pipes or weepholes as shown on the plans. Any fittings shall allow entry of water from the core but prevent intrusion of backfill material into the core material.

6.7.5 Placement. The soil surface against which the geosynthetic drainage composite is to be placed shall be free of debris and inordinate irregularities that will prevent contact between the soil surface and the drain.

6.7.6 Seams. Edge seams shall be formed by utilizing the flap of geotextile extending from the geocomposite's edge and lapping over the top of the fabric of the adjacent course. The fabric flap shall be securely fastened to the adjacent fabric by means of plastic tape or non water soluble construction adhesive, as recommended by the supplier. Where vertical splices are necessary at the end of a geocomposite roll or panel, an 8 inch (200 mm) wide continuous strip of geotextile may be placed, centering over the seam and continuously fastened on both sides with plastic tape or non water soluble construction adhesive. As an alternative, rolls of geocomposite drain material may be joined together by turning back the fabric at the roll edges and interlocking the cuspidations approximately 2 inches (50 mm). For overlapping in this manner, the fabric shall be lapped over and tightly taped beyond the seam with tape or adhesive. Interlocking of the core shall always be made with the upstream edge on top in the direction of water flow. To prevent soil intrusion, all exposed edges of the geocomposite drainage core shall be covered by tucking the fabric flap over and behind the core edge. Alternatively, a 12 inch (300 mm) wide strip of fabric may be utilized in the same manner, fastening it to the exposed fabric 8 inches (200 mm) in from the edge and folding the remaining flap over the core edge.

6.7.7 Repairs. Should the fabric be damaged during installation by tearing or puncturing, the damaged section shall be cut out and replaced completely or repaired by placing a piece of fabric that is large enough to cover the damaged area and provide a sufficient overlap on all sides to fasten.

6.7.8 Soil Fill Placement. Structural backfill shall be placed immediately over the geocomposite drain. Care shall be taken during the backfill operation not to damage the geotextile surface of the drain. Care shall also be taken to avoid excessive settlement of the

backfill material. The geocomposite drain, once installed, shall not be exposed for more than seven days prior to backfilling.

7.0 Method of Measurement.

7.1 Measurement of Geosynthetic Reinforced Soil Slope Systems is on a vertical square foot (meter) basis.

7.2 Payment shall cover GRSS design, materials, and installation of geosynthetic reinforcement, backfill, drainage composites, and geosynthetic erosion mat. Excavation of any unsuitable materials and replacement with select fill, as directed by the Engineer, shall be paid under a separate pay item.